THE DALLES TYPE OF RIVER CHANNEL

J HARLEN BRETZ
University of Chicago

ABSTRACT

Streams of large volume with high gradient, flowing over closely and vertically jointed rock, pluck rather than abrade. They erode rock basins in mid-channel without waterfalls or eddies. The channels are multiple and anastomose very irregularly. Flat-topped, vertically-walled rock islands are left among the channels. The type is the Dalles of Columbia River. Homology between the present Dalles channels and great areas of "scabland" on the Columbia Plateau north of Snake River is indicated. The "scablands" are the channels of enormous Pleistocene rivers across the plateau.

Columbia River flows on the Columbia basalt formation from Rock Island Rapids, near Wenatchee, Washington, to Cooks, Washington, a total distance of 300 miles. Rapids are numerous along this course in low water, at least 40 of them of sufficient prominence to bear names. The greatest of all are the several rapids between Fallbridge, Washington, and The Dalles, Oregon, commonly grouped together as "The Dalles of the Columbia." The river for 125 miles upstream and a few miles downstream flows in the bottom of a broad syncline and the group of rapids is located on a minor upwarp of this floor.

A contour map of the group is shown in Figure 1. The entire length is 12 miles and the total low-water fall of the river surface is 81 feet, of which 20 feet occurs in a sheer drop at Celilo Falls. Ten Mile Rapids is half a mile long. At low water it is a straight chute, 150 to 300 feet wide. Five Mile Rapids (the original "Dalles") is a mile and a half long and similarly at low water is a nearly straight chute 150 to 300 feet wide. Due to an especially favorable setting for a dam and power plant, this rapid has been surveyed carefully and a part of it has been sounded. Three Mile Rapids is a little more than a quarter of a mile long and at low water is a narrow, crooked channel. At extreme high water almost the whole area shown in Figure 1 is overflowed. Celilo Falls then

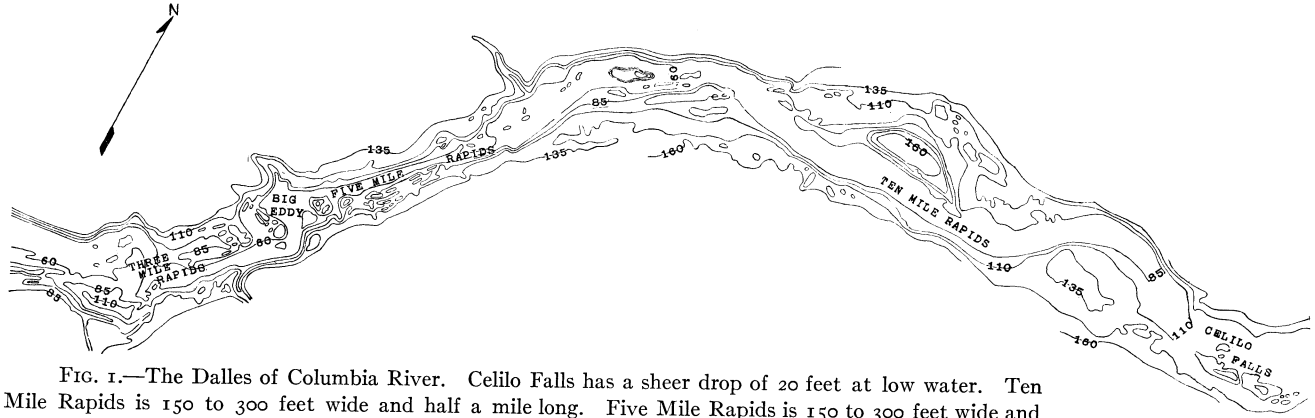

FIG. 1.—The Dalles of Columbia River. Celilo Falls has a sheer drop of 20 feet at low water. Ten Mile Rapids is 150 to 300 feet wide and half a mile long. Five Mile Rapids is 150 to 300 feet wide and a mile and a half long. (See Fig. 2.) At the head is a rock basin in the river bottom 90 feet deep shown in detail in Fig. 4. Big Eddy is 150 to 200 feet deep. Three Mile Rapids is 1,500 feet long. Total length from Celilo Falls to foot of Three Mile Rapids is 12 miles Total fall at high water is 60 feet, at low water 81 feet. At extreme high water almost the entire area here shown is submerged. Redrawn from a map accompanying report, Chief of Engineers, U.S. Army, 1912. Contours renumbered, with mean sea-level as datum.

becomes a rapid; indeed, the entire stretch is one long rapid with a total descent in the surface of the river of about 60 feet.

At the head of Five Mile Rapids the extreme recorded range between high and low water is 93 feet. At the foot, it is 71 feet. At times of notable flood, the river covers most of the area shown in Figure 2 between the navigation canal on the Oregon side and the Spokane, Portland and Seattle Railroad on the Washington side. The gradient of the river surface then is 20 feet to the mile and the flow may exceed one million second-feet.[1] The contoured surfaces shown in Figures 1 and 2 are therefore essentially the bottom of a very large, high-gradient river channel, mapped at low-water stage. From Figure 1 it is clear that the character of the channel floor is the same throughout the entire 12 miles. There is a multitude of flat-topped knobs and small hills of basalt, with precipitous sides descending to the numerous channels which ramify among the knobs. See Figures 4 and 5. Though closely associated, the summits of the knobs and the floors of the channels are at various altitudes. The channels are also of varying depths, widths, and ground plans, and there are many rock basins in them. In Figure 2 these characters are seen to extend to much smaller dimensions than shown in Figure 1 and the precipitous cliffs stand out more clearly. At high water practically all the eminences are submerged, at low water most of the channels go dry. At intermediate stages the pattern of rock islands and channels, and the location of areas of broken water vary greatly.

Figure 6[2] shows the subaqueous topography of a small portion of Five Mile Rapids. The river here at low water is only 150 feet wide at the narrowest place. Tremendous scour of the channel floor is to be expected, yet one is surprised to find that the soundings show a hole in the bottom of the river 170 feet below low-water level, 115 feet below sea-level[3] and at least 90 feet below the channel

[1] A flood of 800,000 second-feet occurs about once in five years. The maximum flood recorded was in 1894 when 1,170,000 second-feet passed The Dalles, Oregon. Only two North American rivers, the Mississippi and the Ohio, have ever had greater measured floods.

[2] I am indebted to Mr. L. F. Harza's report entitled *Columbia River Power Project near The Dalles, Oregon* (Technical Publishing Co., San Francisco, California, 1914), for Figures 2 and 6 and for most of the numerical data used in this paper.

[3] It is 192 miles by river from this place to the ocean.

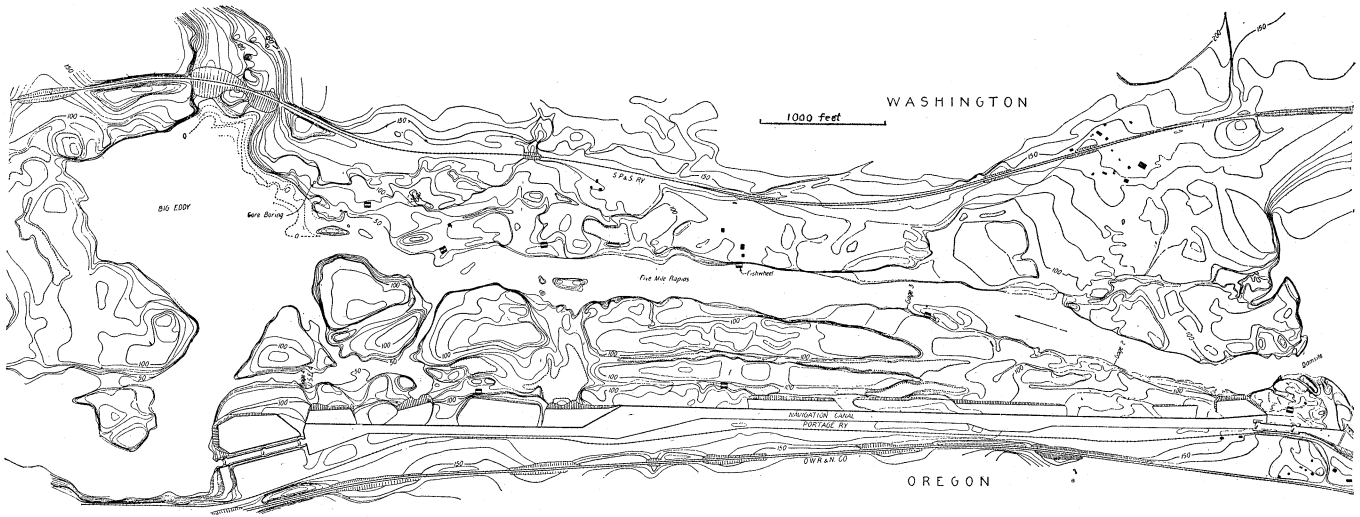

FIG. 2.—Five Mile Rapids and Big Eddy, contoured to low-water level. Contour interval 10 feet. Hachures along the railroads and canal indicate grades and spoil heaps. (After L. F. Harza, *Columbia River Project near The Dalles, Oregon*, Fig. 9.)

floor immediately downstream. The highest altitude of the river bottom between the head of Five Mile Rapids and the ocean is not known. It probably is at least 20 feet above sea-level. The hole in such case is a closed depression 135 feet deep.

And the topographic expression of the bottom of this hole is essentially the same as that of the high water channel floor. There are knobs here 40 to 60 feet high, though their summits are hardly above sea-level, and there are channels with precipitous sides among these knobs.

Big Eddy, immediately below Five Mile Rapids, has not been sounded in detail but its maximum known depth is 150 feet below low-water level. It may be much deeper. No other channel soundings in the 12 miles of rapids are known to the writer. A fair inference is that many submerged knobs, channels, and holes exist.

The basalt exposed in the high-water channels is but little smoothed by abrasion. Though it is disrupted by frost action, the existence of some smoothed surfaces shows that abrasion during high water more than keeps pace with disintegration by frost during the winter low water. The rough, hackly surface of the channel floor is due largely to fracturing and plucking of the closely jointed basalt during floods. So far as abrasion is a major factor, it is from the blows struck by large fragments in transit and results in fracturing rather than wearing. The flattish summits of the inter-channel eminences and the precipitous sides of the channels are equally good evidence of plucking of the horizontally-bedded, vertically-columned lava. And the great hole at the head of Five Mile Rapids, not a pothole either by eddy or by cataract mechanics, is due to the plucking of the jointed basalt by the tremendous currents engendered in the local constriction. The débris from the bottom of the hole is hoisted by these currents at least 90 feet to clear the down-stream rim. Yet the rim remains! Abrasion is a minor item. Plucking is the major item.

Eddies, however, are of great importance in the production of the Dalles type of river channel. Given the incision of a somewhat irregular initial course across a basalt surface, every deflection against the channel wall constitutes a maximum exposure to pluck-

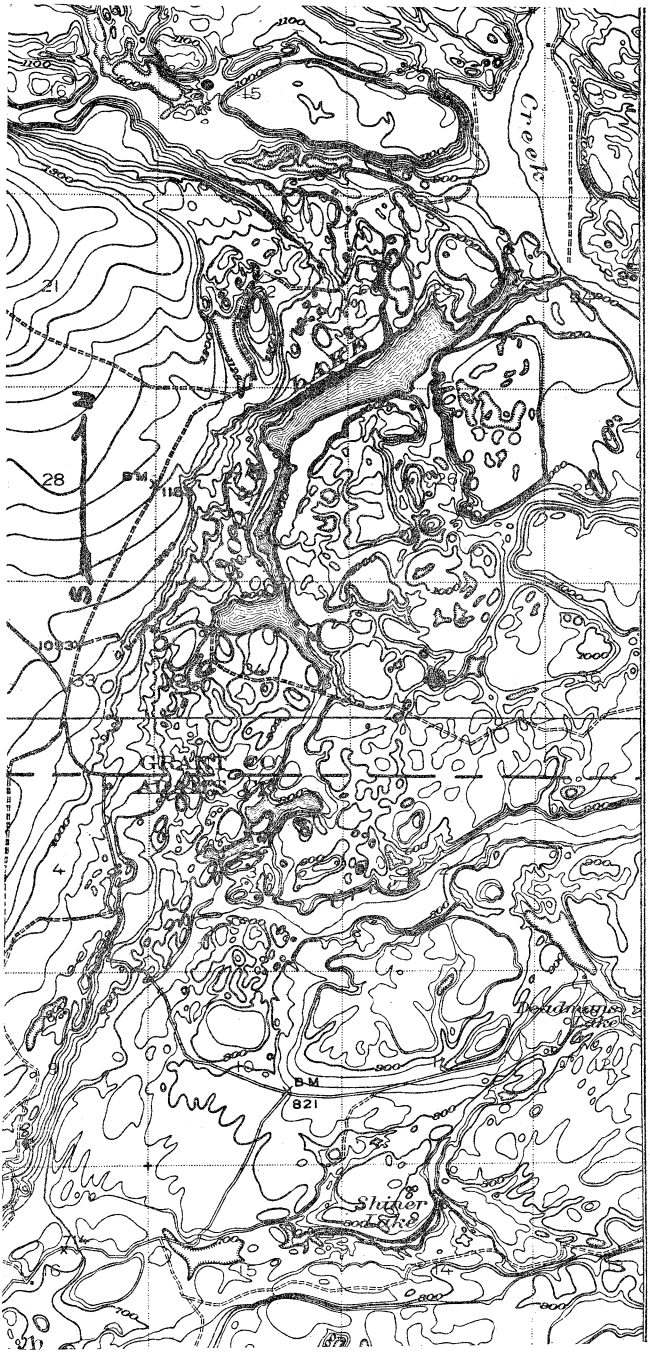

FIG. 3.—Abandoned Dalles-type river channels, a few miles south of Moses Lake, Washington. Part of Corfu Quadrangle. Contour interval 25 feet. The area shown is a part of the Pleistocene Drumheller Channels. The gradient of the deepest channel is about 25 feet to the mile. The flat-topped island-like knobs and hills of varying altitudes bear the same relations to the ramifying channels of varying depths and altitudes of floors as at Five Mile Rapids. The bottom of one rock basin (desiccated) is 75 feet below its downstream rim. Depth of Goose Lake is unknown. It is dammed by a rock rim. Compare its great eddy pocket with Big Eddy at the foot of Five Mile Rapids.

ing. The loss of columns means enlargement of the channel here until a pocket and an eddy or whirlpool off the original main course results. Besides Big Eddy, which is of this genesis, the sites of several such at high water can be located on Figure 2.

Rock Island Rapids, near Wenatchee, Washington, is another Dalles type of river channel with flat-topped and steep-walled islands of basalt interrupting and widening the river despite a much steeper gradient here than above or below. So are the cascades of Spokane River, commonly known as Spokane Falls, in the city of Spokane. There are but few falls here; most of the descent

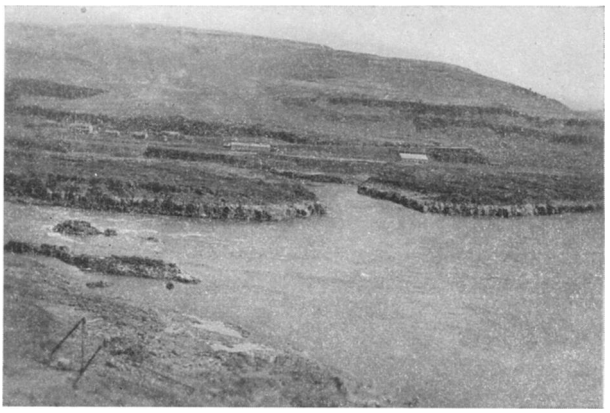

FIG. 4.—South side of Five Mile Rapids, near west end. Photograph taken at an intermediate river stage, looking diagonally downstream.

is by steep chutes which divide and unite and bend about the basalt islands and in some places make noteworthy eddies in great alcoves off the main channel. Island-like hills of basalt, now above the reach of flood waters, exist in the built-up blocks of the city on both sides of the river. They belong to the series and record the earlier stages when the river was experimenting with a number of channels and had not yet selected its future main course. A tract along Yakima River between Mabton and Byron is another example of the Dalles type of river channel, though it has now been entirely abandoned by the river.

It is to be noted that only large streams on the Columbia basalt have Dalles type channels. The determining conditions

for this type of river channel are (1) large volume and (2) high gradient of the stream, and (3) close and vertical jointing of the rock. Where the conditions all exist, and the stream has room to spread at high water, the type results. Where any one of them is lacking, it is not formed. The small streams of the plateau are uniformly without this feature. The large streams in most places have too low a gradient. Adequate volume and gradient, as in many rapids of the Columbia above Rock Island Rapids, fail to produce the type because the proper rock structure is lacking.

FIG. 5.—Five Mile Rapids, near lower end. Photograph taken at an intermediate river stage, looking diagonally upstream.

All Dalles-type channels are early stages in the development of a simple channel. Trenching of a central main channel eventually results and with this trenching the high water channels are gradually abandoned. By this trenching the gradient is lowered, plucking decreases, and the holes in the rock floor disappear by simple abrasion of the higher parts and perhaps also by filling of the lower. The hole 115 feet below sea-level at the head of Five Mile Rapids eventually will be filled in large part.

This leads to a consideration of some abandoned Dalles-type river channels on the Columbia Plateau north of Snake River. There are hundreds of miles of channels of this character on the plateau, none of them along present major rivers, and many of them without even intermittent streams. They constitute the "scabland" of the plateau.[1] Aside from the great width and depth of

[1] Described by the writer in *Bulletin of the Geological Society of America*, Vol. XXXIV, No. 3, and in *Journal of Geology*, Vol. XXXI, No. 8.

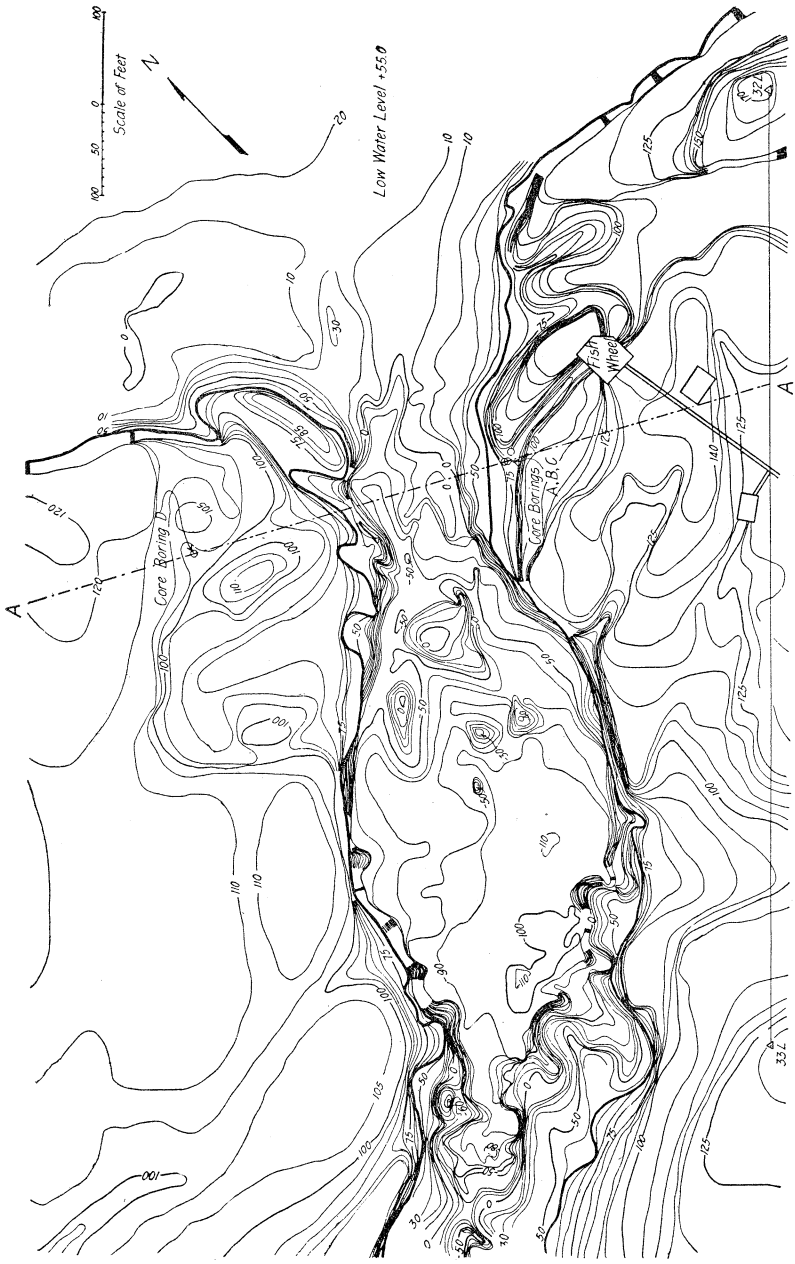

FIG. 6.—Detailed topography of the head of Five Mile Rapids, drawn from land surveys and soundings. Contour interval above low-water level (55 feet A.T.) is 5 feet. subaqueous contour interval is 10 feet. Contours numbered from sea-level. (After L. F. Harza, *Columbia River Power Project near The Dalles, Oregon*, Fig. 10.)

some of them, they are strikingly like those in use at the Dalles of the Columbia today. They possess the anastomosing channels about flat-topped, steep-walled rock islands, the narrows and long chutes, the cataracts, the eddy pockets, the rock basins in their floors, and the steep gradients of the whole. Figure 3 shows a small portion of one tract of abandoned Dalles channels about 8 miles south of Moses Lake. There are many more waiting to be mapped. Figures 7 and 8 show two rock basins in the "scabland" channels in another part of the plateau. Submit the Corfu sheet, showing

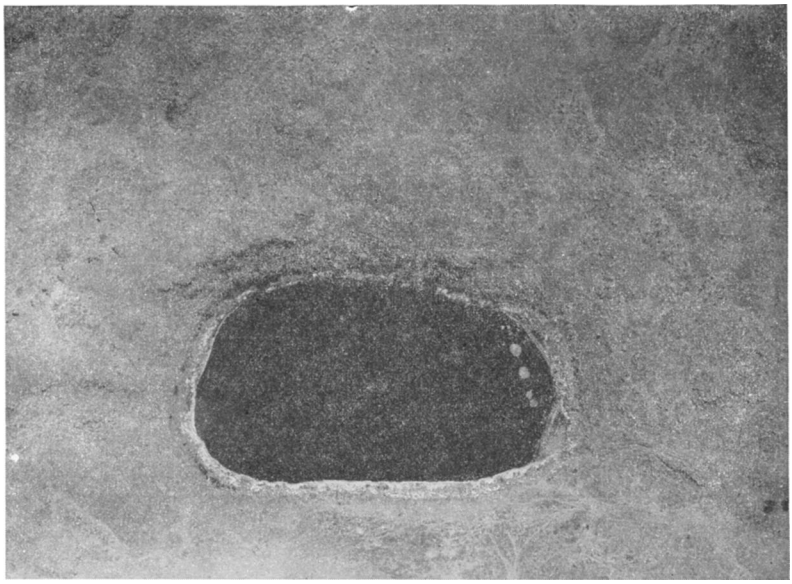

FIG. 7.—A rock basin lake in the abandoned Dalles-type river channels (the scablands) of the Columbia Plateau, near Spokane. Airplane photograph by F. H. Frost.

these channels eroded in solid rock, to any student of land forms. He must admit that they are very exceptional. He will probably add that he has never before seen anything quite like them on a topographic map. The Corfu sheet, just issued by the United States Geological Survey, is the first map to delineate adequately the Dalles type of river channel.[1]

Because of the great number and great magnitude of these features on the plateau, one is tempted to question the explanation

[1] Except Mr. Harza's map of Five Mile Rapids, reproduced in Fig. 2.

of their origin here offered. But, aside from the striking similarities to the Columbia channels near The Dalles, there are many consistently corroborative field evidences,[1] the sum of which cannot be explained in any other way. Such present-day streams as use the scabland channels of the plateau have no Dalles-type channels. They all lack the requisite volume. The ancient streams were prodigious affairs for they carried all the drainage of the Cordilleran ice sheet west of the Rocky Mountain continental divide as far as the longitude of Lake Chelan, Washington. Abrupt loss of volume,

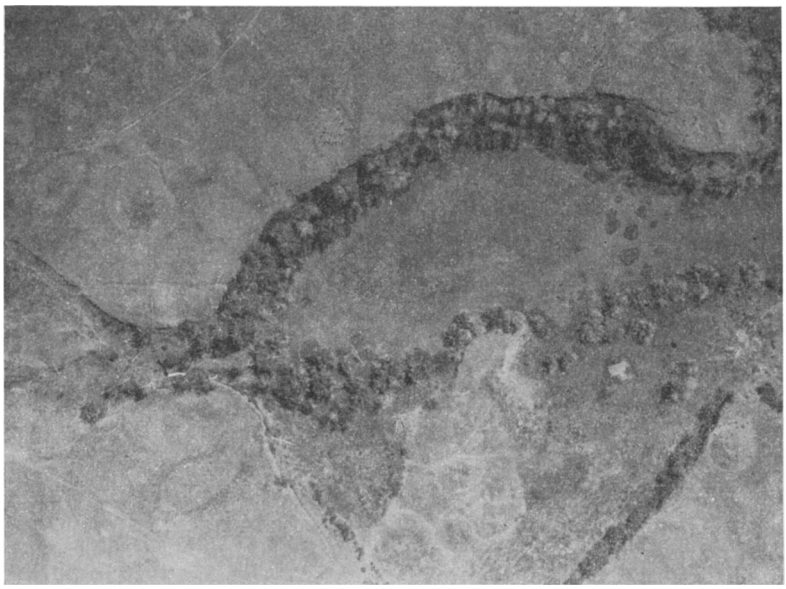

FIG. 8.—A dry lake bed in a rock basin of the abandoned Dalles-type river channels of the Columbia Plateau. A constriction of the channel, very similar to that at the head of Five Mile Rapids, is shown. Talus along the bounding cliffs is covered with shrubs and trees. Airplane photograph by F. H. Frost.

rather than deep trenching and decrease of gradient, decreed the abandonment of these Dalles-type channels. In some cases, the main channels were canyons in dimensions and probably carried all the water toward the close of the epoch, even at the height of summer melting. In other cases, annual flooding of the shallower margining channels probably occurred, similar to that at The Dalles today.

[1] Presented in detail in the writer's paper in the *Journal of Geology*, above noted.